

Form 6 Rack/Yard Mount

Microprocessor-Based Recloser Control

Technical Specifications

Introduction

This specification describes the features of the Kyle Form 6 Rack and Yard Mount Microprocessor-Based Recloser Controls with ProView 4.0.1 application software. The control shall include extensive system protection functionality, including phase, ground and negative sequence overcurrent protection, cold load pickup, over/underfrequency, over/undervoltage, sensitive ground fault, directionality, and sync check.

Analysis tools shall include fault locating, event recording, data profiler, and oscillography functions.

Metering functions shall include demand and instantaneous current on a per phase basis, instantaneous voltage and power factor on a per phase basis, and power (real, reactive, apparent) on a per phase or total basis. Harmonics shall be provided for on a per phase basis. Symmetrical components for both voltage and current shall be displayed along with kilowatt-hours for energy metering. These values shall be recordable in a Data Profiler that contains user selectable inputs and sampling rates.

The front panel Human/Machine Interface (HMI) shall be used to configure the operating settings for the control. It shall also be used to display metering, counter information, control parameters, reset alarms, and provide diagnostic information, including the ability to view at a minimum the 25 most recent event files.

Control parameters shall also be programmed via a personal computer connected to the control through the front panel RS-232 port. The control programming, interrogation, and operations shall be accomplished using Windows® interface software residing on a personal computer.

The ProView application software shall include additional functions used to create and graphically display time current curves and provide the graphical customization platform for configuring user-selected inputs and outputs, configurable event and alarm data, and selectable communication points for serial communication. The user shall be able to connect to the control via the application software and open a scheme from file or device, or open a saved event with a single menu command.

The control shall operate on 50 and 60 Hz systems.

Standards

The Form 6 control has been designed and tested in accordance with the following standards as applicable:

C37.60-2003. American National Standard Requirements for Overhead Pad-Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems.

C37.90™-1989 (ANSI/IEEE). IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

C37.90.1™-2002 (ANSI/IEEE). American National Standard Guide for Surge Withstand Capability (SWC) Tests.

C37.90.2™-1995 (AMCI/IEEE). Standard Withstand Capability of Relays Systems to Radiated Electromagnetic Interference from Transceivers.

Distributed Network Protocol. Basic Four Document Set.

EIA-232-D. Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

IEC-60068-2-30-1980. International Electromechanical Commission Standard for Basic Environmental Testing Procedures – Damp Heat, Steady State.

IEC-60255-5-2000. Insulation Tests for Electrical Relays.

IEC 255-5-1977. Insulation Tests for Electrical Relays.

IEC 61000-4-2-1995 and IEC 60255-22-2-1996. Electromagnetic Compatibility (EMC – Electrostatic Discharge Immunity Tests, Level 4).

MIL-STD-810-F. Random Vibration: Method 514.4 Curve 514.4-1.

Control Housings

Rack Mounting

The design shall be suitable for two units to be mounted side-by-side in a standard 19-inch substation rack. The mounting height shall not exceed 5U. The access to serial communications for configuring the rack-mounted control shall be available on the front of the control, while serial communications and I/O access shall be available on the back panel.

Yard Mounting

The yard mount control shall be housed in a steel weatherproof outdoor cabinet with accessible dual-entry (front and rear) through two doors. Each door shall include gasketing to assure a weathertight seal and include locking provisions for utility grade locks. A minimum of two latch points shall be required for each door. A nameplate shall be attached to the front door. Front door entry shall allow access to the operating panel without exposure to exposed substation battery voltage.

Rear door entry shall allow direct access to all control wiring including substation power, thermostatically controlled heater, serial communications/hardwired inputs and outputs. As part of the housing, a factory-mounted and pre-wired control receptacle shall allow the user a quick-disconnect from the recloser. The control housing shall also have a provision for standard conduit or cable entry. Two vent holes shall provide ventilation, avoiding moisture.

A thermostatically controlled heater rated 70°F ON, 85°F OFF shall be included and powered from 120 Vac or 240 Vac.

Configuration Firmware / Interface Software

The recloser control shall use a Windows® operating system-based interface software. The software, ProView, shall be separate from the recloser control. The executable configuration interface software shall allow the user the ability to save and edit files based upon user requirements independent of connectivity to the control. All settings, metering, and analysis tools shall use standard dialog boxes, including available minimum and maximum values, for each setting.

Firmware upgrades shall be available through direct connection to the dedicated RS-232 port on the control front panel without any additional equipment required.

Temperature Range

The operating range of the control shall be -40°C to +70°C ambient.

The enclosure design shall allow internal self-heating to raise the enclosure interior an additional 15°C, such that all components, assemblies, and sub-assemblies shall operate from -40°C to +85°C. All components selected in the design of the control shall have a temperature rating of -40°C to +85°C or higher. Validation of temperature range through production sorting is not acceptable.

The control shall not be damaged by storage at ambient temperatures from -40°C to +85°C.

Front Operating Panel

The front operating panel shall be intuitively designed to minimize training costs and avoid potential misoperation. The operating panel shall be separated into two sections clearly identified by color-coding or another acceptable user-approved method. The top portion of the control shall be used for programming the control. The lower portion of the control shall be used for operation. The recloser control shall be integrated as a system to include proper status of the recloser on the front operating panel.

Programming/Status

The control programming section shall allow the user LED status indication. Each LED shall be rated for visibility in bright sunlight. The control shall have a total of 25 LEDs available for direct control and recloser status information. As a minimum, dedicated LEDs shall include status indication as follows:

- Control OK
- Control Power
- Control Lockout
- Recloser Open

- Recloser Closed
- A-Phase Fault
- B-Phase Fault
- C-Phase Fault
- Ground Fault
- Sensitive Ground
- Alarm
- Above Minimum Trip
- Indicator 1
- Indicator 2
- Indicator 3
- A-Phase Voltage
- B-Phase Voltage
- C-Phase Voltage
- Frequency Trip
- Voltage Trip
- Indicator 4
- Indicator 5
- Indicator 6
- Indicator 7
- Indicator 8

The user shall be enabled to remove all insert labels (a total of 31 relabeled LEDs) to customize the LEDs as required. Removable labels shall be included with the control to enable the user to easily customize the control for their protection requirements. Removable inserts shall be available to customize LEDs for all 9 Option LEDs and all Target Indicators except CONTROL OK, CONTROL POWER, AND ALARM. Removable inserts and labels shall be designed to enable the user to change inserts without the use of adhesives, labelmakers, or temporary labels.

The user shall have the ability to access critical operation functions through the use of eight Analysis One-Touch Keypads. It is not acceptable to scroll through a series of menus for the following functions:

- Metering
- Reset Targets
- Events
- Lamp Test
- Settings
- Operations Counter
- Alarms
- Change

A sharp, backlit 4 line x 20 character display shall be included in the programming section. The LCD panel contrast shall be field-adjusted to allow for various mounting heights and applications. The LCD shall provide extensive status information regarding the distribution system, recloser, and control using a minimum of eight navigational keypads in an organized menu structure. The navigational keypads shall include accelerated plus and minus keypads for quick setting changes; direct scroll up, down, left, and right keypads; along with immediate enter and menu keypads for direct operation. The LCD shall also use four clearly identified function keys for setting and operation instructions.

The programming section shall also include a DB-9 RS-232 connector for direct connection to a personal computer (PC). The interface shall be designated DCE to directly connect to the serial port of the PC without any special cables or connectors.

Operating Section

The operating section shall allow the user direct open and close operation of the recloser along with pre-defined and customized operating functions.

The TRIP and CLOSE buttons shall have a minimum surface area of 6.45 cm² (one square inch) with a protective guard around the perimeter of each button to prevent incidental trip or close. The TRIP button shall be green and the CLOSE button shall be red. No exceptions to the surface area or color of the TRIP and CLOSE button standards shall be accepted.

The TRIP button shall be hardwired to the recloser independent of the microprocessor. All trip commands from the TRIP Button shall trip the recloser, even in the event of a microprocessor failure.

The CLOSE button shall be connected to the microprocessor for establishing temporary operating requirements such as cold load pickup.

The front operating panel shall include the following push-button keypads with LED Indicators:

- Ground Trip Blocked
- Non Reclosing
- Supervisory Off
- Alternate Profile #1
- Alternate Profile #2
- Alternate Profile #3
- Option #1
- Option #2
- Option #3

The front operating panel shall also include the following:

- Hot Line Tag On/Off Toggle Switch
- Hot Line Tag LED Indicator
- Close Circuit Disable removable link
- RS-232 Port

Operating Power

The operating power shall consist of one of the following options:

- 24 Vdc $\pm$ 20%
- 40 – 140 Vdc universal input power supply

Protocols

Four serial communications protocol options shall be supported in the control. At the time of order, the user shall select the appropriate protocol for the RS-232 and RS-485 serial ports from the available list of protocols.

- Modbus
- DNP3
- 2179
- IEC870-5

The protocol ports are configured as follows:

- Front Panel Port – This port shall be used exclusively with the ProView interface software supplied with the control.
- Rear Panel Ports (2 – Standard supplied RS232 and 1 that is user selectable at time of order) – The rear port selections shall be as follows:
 - RS-485 (Isolated)
 - Serial Fiber Optic
 - Ethernet (Wire or Fiber)
- The user shall configure which back port shall have the communication protocol. The other port shall automatically be assigned ProView protocol.

The RS-485 or serial fiber-optic communications cards shall not support ProView protocol.

Control Security

The control shall have a customer-programmable security code to limit front panel access of control programming and viewing functions to authorized personnel.

There shall be a connection password when communicating between the control and a computer.

Protection Profiles

Four protection profiles shall be provided, each capable of fully specifying the operation of the control. The profiles shall be selected from front push-button overlays or through interface software and serial communication ports. Each protection profile shall include as a minimum:

- Overcurrent Protection
- Over and Undervoltage Protection
- Over and Underfrequency Protection
- Directional Protection
- Sync Check
- Sensitive Ground Fault Protection
- Operation Settings

Time-Current Curve

Time-current curves shall be available for fast and delayed operations. Each time-current shall be selected from a defined fifty curves which can be further customized by the user. The time-current curves shall also be selected from a graphical TCC editor to visualize any modifications prior to configuring the control.

The time-current curves shall include the following modifications for phase, ground, and negative sequence protection:

- Time Multiplier with a range of .1 to 25 in .1 increments.
- Time Adder with a range of 0 to 30 seconds in .01 second increments.
- Minimum Response Time with a range of 0.1 to 1 seconds in .001 second increments.
- High Current Trip with a range of 1 to 32 multiples of minimum trip.
- HCT Time Delay with a range of .016 to .150 second in .001 second increments.
- Reset co-efficient with a range of .1 to 30 in 1 second increments.

Sequence Coordination

A Sequence Coordination feature shall be included which allows the control to step through selected operations in the operating sequence without tripping. The number of Sequence Coordination advances is programmable from one to three operations to provide trip coordination with a downline recloser. This feature shall be independently selectable for each protection profile.

Cold Load Pickup

The control shall include a Cold Load Pickup feature to prevent the control from tripping while energizing non-fault system loads. This feature shall have an independently programmable minimum trip value, time-current curve, reclose interval, and number of operations to lockout for each protection profile. Cold Load Pickup shall also include settings for Time Dial resetting applications, including time dial and reset co-efficient values. Also, direct values, not multiples of minimum trip, shall be provided for high current lockout.

Hot Line Tag

A Hot Line Tag feature that blocks all closing operations for live-line work shall be included in the design of the control as a standard feature. When selected, the control shall use a programmed Hot Line Tag definite time for overcurrent protection operating on one trip to lockout. Hot Line Tag time delay shall be independently selectable for each protection profile.

Fast Trips Disabled

The control shall include a Fast Trips Disabled feature to modify the protection, so that all trip operations use the programmed TCC2. This feature shall be independently selectable for each protection profile. All trip operations shall time on TCC2. Typically, TCC1 is fast and TCC2 is delayed. As an example, the control shall change it's sequence from 2 fast and 2 delayed operations to 2 operations on TCC2 when Fast Trips Disabled is active.

High Current Lockout

A High Current Lockout feature that shall automatically lockout the control when current exceeds a programmable level shall be included in the control. The active shot numbers for the lockout shall be selectable for phase, ground, and negative sequence. This feature shall be independently selectable for each protection profile.

Sensitive Ground/Earth Fault Operation

The control shall include a Sensitive Ground/Earth Fault Trip feature that shall provide tripping of the recloser after a programmable, definite time for ground currents below normal ground minimum trip levels. The feature shall have programmable operations to lockout and reclose intervals independent of the ground settings. This feature shall be independently selectable for each protection profile.

Metering

The control shall provide instantaneous and/or demand metering with programmable integration intervals for the following functions:

- Real and reactive power for each phase and total, including directional, on an individual phase basis.
- Demand currents on a per phase basis.
- Instantaneous currents, including ground current.
- Instantaneous voltage on a per phase basis.
- Instantaneous frequency.
- Positive, negative, and zero sequence voltages.
- Harmonics on a per phase basis for voltage.
- Instantaneous power factor on a per phase basis.
- Metering settings to include demand interval, and alarm thresholds for current, single-phase kW, three-phase kW, single-phase kVAr, and three-phase kVAr.

An onboard Data Profiler shall be provided to record user configured demand values. These values will be taken at a user selectable sampling rate. Based on the number of values recorded the Data Profiler should be able to record a minimum of 30 days worth of data.

Data Profiler

The Data Profiler shall record configurable analog data for a specific period of time. The Data Profiler shall be configured to allow periodic recording with ranges from 1 minute to 24 hours for all selected parameters. The Data Profiler shall be capable of selecting up to 150 analog data points along with 8 user-customized analog data points. The data profiler shall present the data in table form and allow exporting to external spreadsheet application software.

Event Recorder

The Form 6 shall contain capabilities to perform Sequence of Events for up to 33 event types. The event recorder shall include the date and time of the event and appropriate metering analogs based upon event type. Sixteen additional event types can be user-defined through the graphical customization platform. Factory-defined event types include:

- Overcurrent Protection Trip
- External Trip
- Non-Reclose Trip
- External Close
- Lockout
- Reset

The Event Recorder shall maintain a minimum of 90 events.

Recloser Duty Monitor

The Form 6 control software shall be equipped with a Recloser Interrupting Duty Monitor. The Duty Monitor shall accumulate the summation of $I^{1.5}$ for all interrupted currents on each interrupter. This feature shall permit programmable entries to preset the duty of an existing recloser.

Discrete SCADA Communications

The control shall provide a minimum of five configurable output status contacts. Each status contact shall be configurable using graphical interface software to combine status functionality along with Boolean algebra. Default output status shall be: Lockout, Open, Close, Ground Trip Block, and Hot Line Tag. One output status contact shall be a solid state output with a pickup time no longer than two milliseconds.

The control shall also provide a minimum of three configurable control input contacts. Each control contact shall be configurable using a graphical interface software. Each contact shall accept a voltage range of 12-240 Vac, 12-250 Vdc as the wetting voltage. Each control input shall be configured for either a momentary, latched, or latched with precedence contact. Default control input contacts shall be: Supervisory Trip and Lockout, Supervisory Close, and Remote Trip and Lockout.

A discrete interface board shall also be available as an accessory to provide an additional eight output status contacts and eight control input contacts. The discrete interface board shall be user-configurable via the graphical customization platform.

Time Current Curve Editor

Coordination and actual time current modifications shall be available with a graphic interactive Time Current Curve Editor or similar graphical software.

The Time Current Curve Editor shall include a complete database of standard industry recloser time current curves (TCC), both ANSI and IEC types, along with the ability to customize the TCCs with multipliers, constant time adders, or minimum response time adders. Also, the user shall be able to derive their own specific TCC through data point entry. Each modified time current curve shall be able to be identified with a user-customized name and shall be selectable for configuring the control. The grid and format for presenting the TCCs shall have a user-adjustable scale, including the option of presenting multiple TCCs in various user-configured colors. Event size shall be user selectable from 2 to 30 cycles with the capability of recording a minimum of 20 events for a 12 cycle event.

Oscillography

Oscillography shall be provided to present current and voltage waveforms, along with protection function and recloser response status changes.

The recorded values shall be super-imposed on the protection scheme, and the state or value at any point in the scheme shall be displayed. The user shall have the capability to move through the event and watch the response of all available functions. All analog signals, digital inputs, and contact outputs shall be monitored. The oscillography sampling rate shall be a minimum of 16 samples per cycle. The oscillography data on the analog signals shall be post-filtered values.

Idea Workbench

The Idea Workbench graphical customization platform included with the control interface software shall allow the user to program the control using simple graphical logic characters, internal alarms, status, and target. The user shall have the ability to perform logical functions with a combination of these variables using drag and drop functionality supported by the control.

The graphical customization platform shall provide a true graphical programming environment. Logical equation programming is not acceptable.

Over/Underfrequency Protection

The control shall include two-stage operation for both underfrequency and overfrequency protection. Frequency protection shall have the ability to enable either over or underfrequency protection or both functions simultaneously. A fixed time delay ranging from 0 to 100 seconds in .001 second increments shall be available for both over and underfrequency. A frequency restoration function, enabled or disabled by the user, shall be provided to allow the recloser to automatically close should frequency return to within configured settings for a user-settable time. Frequency protection shall be included as part of each protection profile.

Over/Undervoltage Protection

The control shall include single-phase and three-phase undervoltage tripping. The control shall also include three-phase overvoltage tripping. Both over and undervoltage functions shall include a phase pickup, a phase time delay, a three-phase pick-up, and a time delay. Voltage protection shall be included as part of each protection profile.

Directional

Directional functionality shall be included to maintain system coordination from multiple sources, as well as circuit reconfiguration for each profile. Directional shall apply to phase, ground, and negative sequence protection, selected independently. A maximum torque angle shall have a range of 0–90 degrees in 1 degree increments.

Fault Location

The control shall include an impedance-based fault locator based upon the Takagi algorithm. Load-compensated impedance calculation shall be used for calculating the distance. The user shall be able to configure the positive and zero sequence in ohms, and the fault locator line length in kilometers and/or miles.

Sync Check

Sync Check functionality shall include the following applications:

- Hot Line/Hot Bus Closing
- Dead Line/Hot Bus Closing
- Hot Line/Dead Bus Closing
- Dead Line/Dead Bus Closing

Sync Check parameters shall include the following configurable settings:

- Voltage Angle
- Mechanism Operating Delay
- Static Angle Delay
- Dead Threshold
- Live Threshold
- Positive Sequence Dead Threshold
- Upper Voltage Limit
- Lower Voltage Limit
- Lower Frequency Limit
- Upper Frequency Limit
- Fail to Close Timer

Hardware Specifications

Frequency

- 50/60 Hz

Voltage Inputs

- 4 inputs (Each input has a specific PT ratio and phase angle adjustment setting.)
- 30 – 300 Vac
- Burden < 0.1VA. Input impedance ~0.5 Mohm

Control Power Supply

- 240 Vdc $\pm$ 20%
- 40 – 140 Vdc
- 250 W peak input power

Control Contact Inputs (Optically Isolated)

- 9Vdc - 290Vdc (default range)
- 7Vac - 265Vac (default range)

Status Contact Outputs

- 240 Vac/250 Vdc
- Make: 30 A peak, 8 A continuous
- Break: 0.2 A peak
- Pickup Time: <8ms
- Dropout Time: <5ms

Solid-State Contact

- 240 Vac/250 Vdc
- Make: 30 A peak, 8 A continuous
- Break: 10 A peak
- Pickup Time: <2ms
- Dropout Time: <15ms

Local/Remote Communications

- Two EIA-RS-232 serial ports
 - Front Panel – Used exclusively with ProView protocol (DCE)
 - Rear Port – Configurable to be either the default SCADA protocol (DNP, 2179, Modbus, or IEC870-5-101) or ProView protocol (DTE)
- RS-485 / Fiber daughterport – Can be configured exclusively for any one of the SCADA protocols (DNP, 2179, Modbus, or IEC870-5-101) and, as a result, the ProView protocol is active on the rear RS-232 port.

Baud Rate

Baud Rate	Protocol				
	ProView	Modbus	2179	DNP	IEC870-5-101
1200		X	X	X	X
2400	X	X	X	X	X
4800		X	X	X	X
9600	X	X	X	X	X
19200	X	X	X	X	X
38400	X	X	X	X	X
57600	X	X			
115200	X				

Front Panel Display

4 X 20 LCD Display with LED Backlight, Contrast Adjustable

Front Panel Targets

25 Single-Element High-Intensity LED Targets

- 22 are user-configurable.

Front Analysis Keypad

Eight Momentary Contact One-Touch Keypads for Immediate System Analysis

Front Panel Keypad and Controls

- Nine Momentary Contact One-Touch Keypads with LED Indicators for Operating Functions
 - All are user-configurable.
- Large TRIP and CLOSE Momentary Push-Buttons
- Hot-Line Tag Toggle Switch with High Intensity LED Local Indication

Rack Mount Control Dimensions

Without Handles: 220 mm (8.75 in) wide
 222 mm (8.75 in) high
 229 mm (9 in) deep

With Handles: 262 mm (10.25 in) wide
 222 mm (8.75 in) high
 254 mm (10 in) deep

Yard Mount Cabinet Dimensions

400 mm (15.75 in) wide
 710 mm (28 in) high
 340 mm (13.5 in) deep

Operating Temperature

-40°C to +70°C ambient

IEC 68-2-1 & IEC68-2-2

Humidity Test

IEC 68-2-30

Impulse/Dielectric Test

IEC 255-5

Radio Frequency Interference

ANSI/IEEE C37.90.2™-1995 standard

IEC 61000-4-3 level X=35 V/M

IEC 61000-4-2 ESD, Level 4

IEC 61000-4-4 EFT, Level 4

IEC 61000-4-6 Conducted immunity, level 3

Surge Withstand

ANSI/IEEE C37.90.1™-2002 standard

ANSI/IEEE C37.60™-2003 standard (section 6.13.2)

Vibration/Shock Test

MIL-STD-810-F

IEC-255-21-1

IEC-255-21-2

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